The function of the thus described valve is as follows:

The winding **282** is connected to the control unit **26** (FIG. 1). The valve is normally open due to the biasing action of the spring **290**. In connection with the energization of the winding **282** with corresponding electrical energy, the valve member is moved as seen in FIG. **9** upwardly into a position in which the discs **278** are disposed within the valve openings **272** and a through flow of fluid through the valve openings is blocked. As can be seen, there occurs in the closed position of the valve if, for example, an overpressure exists from the left of the valve, that this overpressure acts on the topmost and third topmost discs such that the valve member is biased downwardly, whereby, in contrast, the overpressure is exerted against the bottommost and third bottommost discs to bias the valve member upwardly, whereupon the valve member in totality is in force equilibrium independent of the pressure difference.

An advantage which is realized with the depicted valve is that it can be moved in an unusually rapid manner from the closed position into the open position and vice versa, whereby a precise control is possible with the least possible loss of flow.

In a preferred configuration, the shaft **276** is connected with a position sensor **291**. This position sensor **291** delivers information concerning the exact instantaneous position of the shaft **276** or, respectively, the discs **278**. The control unit **26** controls the energization through the winding **282** such that the real time position of the valve body (**276**, **278**) corresponds at every time point of the movement sequence intervals to the prescribed positions programmed into the control unit. In this manner, it is ensured that the filling amount is the same per cylinder in multiple cylinder motors per unit control time.

It is to be understood that the electromagnetic actuation can be varied in different ways wherein, for example, the cylindrical addition **280** is configured as a magnetic anchor without its own winding. The illustrated embodiment (voice coil) has the advantage of much less magnetic attraction. The valve member can be altered together with the separation wall such that it opens or closes the valve openings by a 90° turn thereof.

The valve shown in FIG. **9** can be used instead of the valve of afore-described embodiments so that the functional advantages associated with the invention can also be achieved with this configuration. The closing time point of the valve is set increasingly ahead of the closing time point of the intake valve in dependence upon decreasing performance demands. The opening time point is accommodated independently of the closing time point to the rate of rotation of the motor in order to achieve the afore-described charging effect connected with reduced intake effort.

It is advantageous if the opening time point of the valve is varied, in connection with the same maintained closing time point or, respectively, the same maintained cylinder filling amount (air effort), so as to achieve as well the charging effect to optimize the charge transition in connection with partial loading.

The depicted effect can be characterized as a partial load resonance charge for minimizing the charge transition loss.

The specification incorporates by reference the disclosure of German priority document 198 30 575.3 of Jul. 8, 1998 and European Patent Application priority document PCT/EP99/04660 of Jul. 5, 1999.

The present invention is, of course, in no way restricted to the specific disclosure of the specification and drawings, but also encompasses any modifications within the scope of the appended claims.

I claim:

1. A charge control apparatus for a reciprocating internal combustion engine, the reciprocating internal combustion engine having at least one cylinder in which a piston is reciprocably moved by a crankshaft, the cylinder having at least one intake conduit and an intake valve which opens and closes the intake conduit as a function of the rotation of the crankshaft and having at least one outlet conduit and an outlet valve which opens and closes the outlet conduit as a function of the rotation of the crankshaft, the charge control apparatus comprising:

a rotary disc valve disposed in the intake conduit upstream of the intake valve, the rotary disc valve having a rotatable member rotably mounted in a housing and connected to an electric motor operable to move the rotatable member between a position in which the rotatable member closes the intake conduit and a position in which the rotatable member permits flow along the intake conduit to the intake valve; and

a control unit for controlling the operation of the electric motor as a function of the engine performance demand indicated by an engine performance demand element to thereby effect movement of the rotatable member of the rotary disc valve such that the closing time point of the rotary disc valve at which the rotatable member closes flow through the intake conduit is set increasingly ahead of the closing time point of the intake valve as a function of decreasing engine performance demands.

2. A charge control device according to claim **1** and further comprising a torsion stiff and flexible connection coupling for interconnecting the rotatable member and the electric motor.

3. A charge control device according to claim **1** wherein the electric motor includes a magnetic pole rotor and the rotatable member and the electric motor are configured to operate with one another as an electromagnetic rotational unit.

4. A charge control device according to claim **1** wherein the electric motor which includes a magnetic field winding stator, and the housing together form an electromagnetic rotational unit.

5. A charge control device according to claim **1** wherein the cylinder includes two intake conduits each having a respective intake valve associated therewith, a rotary disc valve is disposed in each intake conduit, and each rotary disc valve is connected to a separate motor for independent actuation of the rotary disc valve.

6. A charge control apparatus for a reciprocating internal combustion engine, the reciprocating internal combustion engine having at least one cylinder in which a piston is reciprocably moved by a crankshaft, the cylinder having at least one intake conduit and an intake valve which opens and closes the intake conduit as a function of the rotation of the crankshaft and having at least one outlet conduit and an outlet valve which opens and closes the outlet conduit as a function of the rotation of the crankshaft, the charge control apparatus comprising:

a separation wall extending lengthwise within the intake conduit and having a serpentine shape and a plurality of valve openings each extending transverse to the intake conduit length;

a shaft;

at least two closure members fixedly disposed on the shaft and each associated with a respective valve opening for opening and closing the respective valve opening in correspondence with movement of the shaft, one of the

closure members being disposed on one side of the serpentine separation wall and this other closure member being disposed on the other side of the serpentine separation wall such that the pressure differential acting on the closure members in their closed positions is compensated;

a magnetic stroke actuator for moving the shaft longitudinally in one direction so as to effect closing of the valve openings in the serpentine separation wall by the respective closure members associated therewith and for moving the shaft longitudinally in an opposite direction so as to effect opening of the valve openings in the serpentine separation wall by movement of the closure members away from the valve openings; and

a control unit for controlling the operation of the magnetic stroke actuator as a function of the engine performance demand indicated by an engine performance demand element to thereby effect movement of the closure members such that the closing time point of the valve openings at which the closure member close the valve openings is set increasingly ahead of the closing time point of the intake valve as a function of decreasing engine performance demands.

7. A charge control device according to claim 5 wherein there are four valve openings in the serpentine separation wall and four closure members each associated with a respective valve opening.

8. A method for controlling the operation of a reciprocating internal combustion engine, the reciprocating internal combustion engine having at least one cylinder in which a piston is reciprocably moved by a crankshaft, the cylinder having at least one intake conduit and an intake valve which opens and closes the intake conduit as a function of the rotation of the crankshaft and having at least one outlet conduit and an outlet valve which opens and closes the outlet conduit as a function of the rotation of the crankshaft, an engine performance demand member whose position controls the amount of fresh air charge introduced through the intake conduit to the cylinder, and a charge control apparatus including a rotary disc valve disposed in the intake conduit upstream of the intake valve movable between a position in which the rotary disc valve closes the intake conduit and a position in which it permits flow along the intake conduit to the intake valve, the method comprising:

controlling the opening of the rotary disc valve in the intake conduit to precede the opening of the intake valve such that, when the rotary disc valve is moved into its open position in the intake conduit while the intake valve is still closed, a pressure wave produced by the vacuum existing between the rotary disc valve and the intake valve arrives, after reflection on the open end of the intake conduit, at the intake valve substantially contemporaneously with the opening of the intake valve, whereby the intake effort performed by the piston in drawing in a fresh charge into the cylinder is reduced.

9. A method for controlling the operation of a reciprocating internal combustion engine, the reciprocating internal combustion engine having at least one cylinder in which a piston is reciprocably moved by a crankshaft, the cylinder having at least one intake conduit and an intake valve which opens and closes the intake conduit as a function of the rotation of the crankshaft and having at least one outlet conduit and an outlet valve which opens and closes the outlet conduit as a function of the rotation of the crankshaft, an engine performance demand member whose position controls the amount of fresh air charge introduced through the intake conduit to the cylinder, a separation wall extending lengthwise within the intake conduit and having a serpentine shape and a plurality of valve openings each extending transverse to the intake conduit length, a shaft, at least two closure members fixedly disposed on the shaft and each associated with a respective valve opening for opening and closing the respective valve opening in correspondence with movement of the shaft, one of the closure members being disposed on one side of the serpentine separation wall and the other closure member being disposed on the other side of the serpentine separation wall such that the pressure differential acting on the closure members in their closed positions is compensated, and a magnetic stroke actuator for moving the shaft longitudinally in one direction so as to effect closing of the valve openings in the serpentine separation wall by the respective closure members associated therewith and for moving the shaft longitudinally in an opposite direction so as to effect opening of the valve openings in the serpentine separation wall by movement of the closure members away from the valve openings, the method comprising:

controlling the movement of the closure members to effect opening their associated valve openings in the serpentine separation wall in the intake conduit to precede the opening of the intake valve such that, when the valve openings in the serpentine separation wall in the intake conduit are open while the intake valve is still closed, a pressure wave produced by the vacuum existing between the valve openings in the serpentine separation wall in the intake conduit and the intake valve arrives, after reflection on the open end of the intake conduit, at the intake valve substantially contemporaneously with the opening of the intake valve, whereby the intake effort performed by the piston in drawing in a fresh charge into the cylinder is reduced.

10. A method according to claim 8 and further comprising controlling the movement of the rotary disc valve as a function of a selected one of the charging volume and the charging pressure of a charging apparatus.

11. A method according to claim 8 wherein the reciprocating internal combustion engine includes a series of exhaust gas turbo chargers and an exhaust gas distribution valve is controlled to effect the immediate impact of exhaust gas on the exhaust gas turbo chargers as a function of the control of the rotary disc valve.

12. A method according to claim 11 wherein each exhaust gas turbo charger includes a variable intake geometry which is controlled as a function of the control of the rotary disc valve.

13. A method according to claim 9 and further comprising controlling the movement of the closure member to open and close the valve openings in the serpentine separation wall in the intake conduit as a function of a selected one of the charging volume and the charging pressure of a charging apparatus.

14. A method according to claim 13 wherein the reciprocating internal combustion engine includes an exhaust gas turbo charger and an exhaust gas valve is controlled to effect the immediate impact of exhaust gas on the exhaust gas turbo charger as a function of the control of the closure members.

15. A method according to claim 14 wherein the exhaust gas turbo charger includes a variable intake geometry which is controlled as a function of the control of the closure members.

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